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# NASA TECH BRIEF

## *Lewis Research Center*



# Thermal Conductivity and Electrical Resistivity of Porous Materials

Thermal conductivity of porous material is an important property in determining the temperature distribution in a coolant and in the porous structure in transpiration cooling. Due to the irregularity of the microstructures, confident, theoretical calculation of thermal conductivity of porous materials is extremely difficult. Existing prediction methods are based on certain simplifications such as parallel cylinders, laminates in series, spheres dispersed in a conducting medium, etc. Even with a well-defined microstructure, the problem remains complex due to the existence of the interface resistance. Therefore, with the exception of parallel cylinders, a semi-empirical approach employing experimental data has been the only practical way of predicting the thermal conductivity of porous materials.

A study was conducted to provide experimental data of thermal conductivity and electrical resistivity of (1) woven and sintered wire mesh made from 304L stainless steel wire, (2) 304L stainless steel sintered spherical powder, and (3) OFHC (oxygen free high conductivity) copper sintered spherical powder. Three different porosities (.093, .203, .385) of each material were tested from a temperature range of 100°C to 1000°C and the data tabulated in a series of tables and charts. The data were correlated into equations and compared with other published data and correlations.

It was found that the thermal conductivity, $\lambda$, and electrical resistivity, $\rho$, can be related to the solid material properties, $\lambda_0$ and $\rho_0$, and the porosity, $\xi$, of the porous matrix regardless of the matrix structure by the following correlation equations:

(1) For sintered powder and woven wire mesh, the dimensionless thermal conductivity can be represented by

$$\frac{\lambda}{\lambda_0} = \frac{1-\xi}{1+10\,\xi^2}.$$

and the dimensionless electrical resistivity is given by

$$\frac{\rho_0}{\rho} = \frac{1-\xi}{1+11\,\xi^2}$$

(2) Within the temperature range where there is no magnetic transformation; the thermal conductivity of porous metals is related to the electrical resistivity and temperature, T, by the Wiedermann-Franz-Lorenz equation:

$$\lambda = \frac{LT}{\rho} + b$$

For a high conductivity material, the Lorenz constant, L, and the lattice component of conduction, b, are independent of porosity. For low conductivity materials, the lattice component depends on the porosity.

For low porosities, the calculated data compared well with published data and correlations. The departure of the high porosity data from existing correlations was cause for development of correlation equations applicable to the full span of porosities (0 to 100%). Utilizing only the experimental data of the above porous materials, full span correlations were developed. The published data of others covering the full span were then applied to the correlations in order to establish their validity throughout the span. The materials of others differed

(continued overleaf)

not only in matrix structure (e.g., foametal, feltmetal, and nonspherical sintered powders), but also in solid material properties. Such variances in material properties did not cause departures from the new correlations and proved the correlations applicable.

## Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA CR-120854 (N72-19634), Thermal Conductivity and Electrical Resistivity of Porous Material

2. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10587

## Patent status:

NASA has decided not to apply for a patent.

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